A REVIEW OF HERBICIDE USE IN NEW ZEALAND ORCHARDS

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Summary

Over the last 15 years, most deciduous orchards in the main producing areas of New Zealand have been managed with permanent swards. These swards are controlled by regular mowing. Vegetation about the tree trunk is controlled, mainly by herbicide application, to improve working conditions, reduce the risk of harbouring certain diseases and pests, and improve spray penetration. Limited use was made of 2,4,5-T and 2,2-DPA while other materials were used about waste areas and buildings, but herbicides were not generally accepted until the introduction of amitrole. Materials now in common use include amitrole, paraquat, a paraquat-diquat formulation, and simazine. Costs of using these materials are competitive with hand removal of weeds about trees. There is a need for a safe material with persistent action also suitable for controlling clover (*Trifolium* spp.) docks (*Rumex* spp.) and sorrel (*Rumex acetosella*) which are the main problem species of weeds encountered in orchards where the above herbicides are in use.

THIS PAPER covers broadly the problem of weed control in New Zealand orchards and reviews the orchard use of herbicides over the last 15 years. Consideration is given to the practical and cultural advantages associated with weed control. No attempt will be made to cover in detail technical considerations associated with individual herbicides.

Control of unwanted under-tree vegetation may have direct or indirect advantages influencing the efficiency of fruit production, total yield, and fruit quality. All these factors have an important influence on returns to the grower. The cost of controlling weeds in vine and orchard crops is also an important item of expenditure.

Today up to 60% of deciduous orchards in the main producing areas are managed with permanent swards. Most citrus orchards are grown with some type of permanent under-tree vegetation, its nature being dependent on the size and density of the planting and resulting light penetration.

Most grapes are grown under cultivation with herbicides used about the vines, while both clean cultivation and permanent swards are encountered in tamarillo and Chinese gooseberry plantings. There is an increasing tendency to grow permanent crops in a clover-dominant sward. This practice has been associated with the increasing production in all fruit-growing areas and, while the increases cannot be attributed to this method of soil management, it is considered to have a favourable influence provided adequate moisture is available during summer.

The advantage of permanent sward includes its influence on maintaining a high soil organic matter level, which assists the development or retention of good soil structure, erosion is minimized, working conditions are improved, so that time required for tree access during pruning, thinning

and harvesting operations is reduced, and machinery for harvesting or other cultural operations may be used under adverse soil moisture conditions. Disadvantages are associated with the rank growth which occurs under or near trees, in areas inaccessible to mowers, interfering with thorough spray application, harbouring and encouraging certain diseases or pests, and delaying cultural operations. Young plantings may also be slow to develop in competition with an establishing sward. Herbicides are commonly employed to reduce these problems. They have entirely replaced weed removal by hand clipping, which was commonly practised prior to 1950.

Herbicides are also in use preparing and maintaining new planting sites, assisting with weed control along rows of semi-intensively planted apples (e.g., 12 ft × 16 ft) and in waste areas such as headlands and about packing sheds and buildings. Herbicides will often reduce the amount of mowing required if they are employed in areas where a full mower cut is utilized to remove a strip of growth 1 to 2 ft wide.

It is difficult to estimate the loss of production due to weed growth in orchard and vine crops. Under the present system of management, loss of yield would be small but fruit quality and efficiency may be reduced by the presence of weeds. Figures available from America indicate that the potential production of apples is reduced by 2.4% by weeds. All diseases and pests may be responsible for a reduction of 19.2% (U.S.D.A., 1965). Cramer (1967), using these figures as a basis for estimating losses in other areas of the world, claims that potential world production of apples, pears, stonefruits and citrus is reduced by 3% by weeds. Weeds in grapes cause an estimated crop reduction of 10 to 11.6%.

Potential production may be reduced in several ways. Disease-producing organisms are not normally harboured in weeds. Weeds, however, can influence the microclimate about the base of trees by maintaining an artificially high humidity. This may contribute to the incidence of collar rot infection by *Phytophthora* sp. (Smith, 1955), provide or extend conditions suitable for production of spores from the bracket fungus of the silver leaf organism (*Stereum purpureum*), prolong the discharge of ascospores from black spot infected leaves on the ground, and provide ideal conditions for spore production of brown rot infected citrus fruits (*Phytophthora citrophthora*).

Some weeds act as an alternate host to pests of deciduous or evergreen fruits. Two-spotted spider (*Tetranychus urticae*) may overwinter on growth under trees. Certain mealy bug species (*Phenacoccus* sp., *Pseudococcus* spp.) also live or survive on weeds under trees. Plantain (*Plantago* spp.) and other weeds are a food source for leaf roller caterpillars (*Epiphyas postvittana*).

Dense weed growth may prevent the penetration of sprays about the base of the tree and increase the incidence or carry over from season to season of mealy bug (*Pseudococcus* spp., *Phenacoccus* sp.) woolly aphid (*Eriosoma lanigerum*), mite (*Tetranychus urticae*) and leaf curling midge (*Dasyneura mali*, *D. pyri*).

In some orchards growers have used sheep, during winter months, to clean up rank growth made during autumn. Often autumn to spring soil conditions do not permit the use of mowers. Because of the extensive use of DDT in orchards, this practice is no longer permitted and other means of weed control must now be employed.

It is therefore desirable to limit or eliminate under-tree vegetation, particularly that occurring close to the tree trunk and lower branches.

METHODS FOR ORCHARD WEED CONTROL

Mechanical mowers or cultivators are used for between-row control of vegetation. An area is often left about the trunk of the tree, or along tree rows, where weeds are free to grow. Herbicides have proved particularly useful in restricting weed growth in these areas. They are more readily applied and competitive in price.

Hand cultivation about trees is now seldom practised, being replaced by suitable herbicides.

Mulching of areas about trees with organic material is used, particularly when young trees are establishing, but herbicides are now commonly applied when the trees are two years or more old.

Most herbicides used in orchards may be applied through the normal orchard spray application equipment or a special unit employed. A 6 ft long twin jet boom is normally used to facilitate application under trees.

THE IDEAL ORCHARD HERBICIDE

There is no ideal herbicide available for orchard use. Consequently limitations must be placed on their use or growers must tolerate certain disadvantages. An ideal herbicide for orchard use may never be developed. The following would be the main requirements:

- (1) Have no effect on fruit trees when applied to the soil or if carried into the root zone of the tree.
- (2) Have no adverse effects following repeated applications or accumulation in the soil.
- (3) Be safe to apply to the trunk of all types of trees and vines.
- (4) Possess sufficient residual value to provide weed control for six months.
- (5) Have a sufficiently wide spectrum to enable control of weeds, grasses and clovers commonly found in New Zealand orchards.
- (6) Be safe to use on several types of fruit trees normally grown together and safe on trees of all ages.
- (7) Have knockdown action on established vegetation.
- (8) Be safe to use in spray equipment used for application of insecticides, fungicides, etc.
- (9) Have sufficient safety and adequate activity to permit application with hand equipment giving variable rates of application per treated area.
- (10) Cause no residues in fruit.
- (11) Be competitively priced with alternative methods of vegetation control.

Today growers have a limited range of materials which enables some of the more important requirements to be met. By selecting materials, mainly according to the season of use, efficient vegetation control programmes have been developed.

THE TRENDS IN HERBICIDE USE

Arsenical and weed oil sprays were used about orchard buildings and headlands to a limited extent in the 1950s. 2,4-D and 2,4,5-T were applied in waste areas and, in established orchards, for special problems, usually involving spot applications. Used carefully, these hormones have caused no ill-effects.

The general application of herbicides in orchards was first accepted in the late 1950s, when 2,2-DPA was suggested for grass control. This

material was rather slow in action and at recommended rates (2½ to 5 lb per treated acre) gave inadequate control of many grasses (Taylor, 1964).

Possibly because of unfortunate experiences on other crops, and also owing to the undesirable properties of the early substituted urea products, these and later products have not been accepted by orchardists.

Although the use of 2,2-DPA was accepted by some orchardists, it was rapidly replaced by amitrole-ammonium thiocyanate combination. This material is now in very common use in all types of orchards and vineyards. Its use is restricted to the post-harvest to spring period and experience with plant safety has been very favourable despite its water-soluble nature. Recommended rates of application are for 2 lb a.i. per treated acre, although with methods of application in common use rates of at least double this are often applied to individual trees. Rank growth may receive up to 4 lb a.i. per treated acre. Some foliage necrosis of a minor nature is occasionally seen when excessive rates are applied or tanks are drained near trees. The one application made in early spring will keep the under-tree area free of weeds until about late November or December. Where herbicides have been used for some time or the ground is heavily shaded, the single application can be adequate until near harvest. Often weed seeds, sometimes introduced by birds (e.g. *Solanum* spp.), germinate and require controlling in the under-tree area. In most orchards, grasses, clover and various weeds invade the treated area from the adjacent mown sward. Amitrole has been associated with the development of clover and dock domination in treated areas. Young docks are controlled but older plants are tolerant. To avoid injury and residues in fruit, amitrole should not be applied after fruit formation. It is not persistent and in most orchards follow-up applications of other materials are required.

Some growers use simazine to extend the life of amitrole. Other combinations used with simazine include paraquat and combined paraquat-diquat formulations. Possibly the most efficient method is to make the simazine application to bare soil and this is also practised to a limited extent. Following the spring amitrole the majority of orchardists rely on two further applications of paraquat or paraquat-diquat to give a full season's control in deciduous fruits. Generally, the addition of simazine to the first of these sprays will prevent the germination of seedlings and make the second application unnecessary. The choice of method depends largely on the availability of labour for making the second application. Some growers with a high demand for labour from commencement of harvesting prefer to apply simazine in late November or December. Simazine may also be used along the rows or about trees in cultivated orchards. At present some caution is used when recommending simazine for stonefruits. There is less evidence available on its safety on these crops but no problems have been encountered on mature stonefruit trees treated in New Zealand. Recommended rates are for 1 to 2 lb a.i. per acre but some use is made of 4 lb.

Apart from lack of residual life, paraquat and diquat approach very near to the orchardist's ideal herbicides because of their rapid action and breakdown on contact with soil. Unfortunately, they tend to develop clover-dominant swards which can be a disadvantage in some areas where the clover harbours pests. Recently a combination paraquat-diquat proprietary formulation has been available for orchard use. This material is formulated with wetting agents apparently sufficient for application with relatively low volumes of water. Fruit-growers tend to apply large

volumes of water per treated acre and often additional wetting agent improves the effect on dense foliage. When used throughout the year, two or usually three applications of the bipyridylum herbicides are required for suppression of under-tree vegetation to an acceptable extent. More applications are required for total control of vegetation. Paraquat-diquat are now used in citrus orchards and vineyards. Their use is generally avoided until young deciduous trees are at least two years old but this practice is probably not necessary. Recommended rates are for 1 to 1.25 lb per treated acre. There is a wide tolerance for inefficient application.

A range of experimental materials are currently being evaluated. Those used in larger quantities on grower properties with promising results have included 2,6-dichlorothiobenzamide, dichlobenil, terbacil and diuron.

THE COSTS OF USING HERBICIDES

There are two components in the costs of applying herbicides. One is the cost of the material and the other is the cost of applying it in terms of labour and machinery. Before selecting a herbicide, one must also consider costs of alternative methods of vegetation control. It is possible to obtain close-to-tree vegetation control with the use of swinging arms on rotary mowers. These reduce but do not eliminate the need for herbicides. After the December period, it becomes difficult to mow close to the tree owing to fruit weighing down the branches. Hand removal of weeds is sometimes practised but is now seldom seen. Costs involved here vary depending on the physical ability of the person employed. Often the labour employed for this work could also be more profitably employed if an alternative method of control was available with a lower labour input. Assuming that a labour cost of 80c per hour is used, a very able worker removing light growth would take about 2½ hours to chip clear an area of 3 ft diameter round 100 trees. This represents a cost of 2c per tree and must be regarded as a minimum cost. With heavier vegetation, such as that present in spring, the labour cost per tree could increase to 6c per tree. Costs would also be higher if higher paid workers were employed or a larger area cleared.

Labour costs associated with the application of herbicide sprays are much lower. To facilitate hand application, two persons, one to drive the tractor and sprayer and the other operating the spray lance, are usually employed. The time required for application depends on the speed at which the person can walk and spray. The minimum volume that can be applied by hand application is 250 gal per treated acre (Boyce, 1966) and this is applied to 100 trees during a spraying time of approximately 200 seconds. If the tractor is driven at 1½ mph along each row of trees, the area about 100 trees spaced at 20 ft × 20 ft may be sprayed in approximately 15 minutes. On the same basis as before, labour costs for two persons would amount to 40c per 100 trees. To this should be added 50% for time taken to turn into rows and the mixing of spray materials. Total minimum labour costs would amount to 60c for two persons per 100 trees at 20 ft × 20 ft spacings. Costs for spraying semi-intensive plantings (12 ft between trees) would be 30% less per 100 trees. Since some orchardists pay more than 80c per hour (e.g., \$1.00) the range of labour costs could be from 60 to 75c for 100 trees at 20 ft spacings or 30% less for semi-intensive blocks. This cost is also reduced by some growers by utilizing fixed booms or using an extra person to allow two rows to be sprayed at once.

TABLE 1: COSTS OF MATERIALS USED IN NEW ZEALAND ORCHARDS

Material	Price per gal or per lb	Recommended Rate per Treated Acre*	Cost per 100 trees Spaced 20 ft × 4 ft area	Cost per 100 trees Spaced 12 ft × 16 ft 4 ft strip
paraquat		1.0 lb (4 pt)	44c	\$1.33
paraquat-diquat		0.9 lb (4 pt)	37c	\$1.10
amitrole-ammonium thio-		2.0 lb (1 gal)	31c	\$0.93
cyanate		2.0 lb (4 lb)	51c	\$1.52
simazine 50% w.p.				

*Rates recommended by Boyce (1966)—rates for current formulation in parentheses. Cost of wetting agents, maximum range 0.15 to 4c per 100 trees has been neglected.

TABLE 2: COMPARATIVE COSTS OF SELECTED CONTROL PROGRAMMES FOR 100 TREES PLANTED AT 20 ft × 20 ft SPACINGS

	Spring	Nov.—Dec.	Summer	Total
Hand chipping	\$2.00–\$6.00	\$2.00	—	\$4.00–8.00
amitrole	\$3.61			
paraquat (2 appln.)		\$3.74	\$3.74	\$11.09
amitrole	\$3.61			
paraquat (1 appln.)		\$3.74		\$7.35
amitrole	\$3.61			
paraquat plus		\$3.74		
simazine		\$0.51		\$7.86
Hand chipping	\$6.00			
simazine	\$3.81			\$9.81

Note: Cost of application based on 37c per tree

It is difficult to fix a cost for the machinery used. Using contractors' rates, and deducting \$1.00 per acre for labour, one could allow \$2.50 for 20 ft spacings or \$1.50 for 12 ft spacings per 100 trees.

Total labour and machinery costs of application therefore amount to 3.1 to 3.3c per tree at 20 ft spacings or 1.9 to 2.0c at 12 ft spacings depending on hourly rates of pay.

An indication of the relative present-day costs of materials is given in Table 1. The areas sprayed are based on those given by Boyce (1966) and are representative of commercial practices. Normally the area kept free of vegetation by hand removal would be 3 ft $\times$ 3 ft or less.

The figures presented in Table 2 are based on sprayer operation costs of 3.3c a tree. These costs have been estimated and may be above what most growers consider they are expending. However, they do illustrate the relatively small cost of the herbicide and the competitive position of herbicide use versus hand removal of vegetation. Because of the various assumptions made and individual variations encountered from orchard to orchard, these costs must be regarded as artificial and detailed comparisons cannot be justified.

Herbicides are now well accepted in deciduous orchards. Some materials are being used under vines, brambles, and citrus. More information is required on the use of herbicides on brambles, citrus, grapes and Chinese gooseberries. Results in other fruit crops are in general satisfactory and the costs involved compete with other methods of management. There is, however, need for a new herbicide, safe for orchard use, with residual action to reduce the number of applications required. Broader spectrum or special herbicides are required to control problem weeds or herbicide induced dominant species. Problem under-tree vegetation commonly encountered includes docks, sorrel and clovers. These are often found after repeated applications of the standard materials and at present are difficult to eradicate with currently accepted products.

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